FROM Clint Tillman [redacted]

9 August 1969

SUBJECT Simulating the RR-CDU Interface When the RR is in the SLEW or AUTO (not LGC) Mode in The FMES/FCI LABORATORY.

SUMMARY

Research has been done by the staff of the FCI Laboratory to find a way to reproduce without an actual radar pedestal the RR-CDU interface condition that exists when the RR is moded to SLEW or AUTO. Mr. Dvorkin devised a setup using a Resolver Circuit Tester (Apollo GSE) kindly loaned by AC Electronics that causes the CDU's to slew at essentially 6.4 KC. This setup was enabled during a nominal G Mission descent using the LUMINARY 1A Flight Program. The alarm conditions experienced by Apollo 11 were essentially reproduced.

The software performance of this simulation was analyzed and it is concluded that this input to the RR CDU's should permit a valid verification of the fix (PCR 848) in LUMINARY 1B. Further, we believe that this run also provides hybrid simulator confirmation of the diagnosis of the alarm condition in Apollo 11.

DISCUSSION OF THE SETUP

Along the lines of the recommendation in LAV-500-940 Mr. Marty Dvorkin researched several possibilities for injecting signals into the front ends (A/D) of the RR CDU channels to induce the CDU's to output at effectively slew speeds (6.4 KC). This investigation concluded that use of aresolver would be the best arrangement. Thanks to the cooperation of the AC Electronics Site Support group at BPA he obtained the loan of a Resolver Circuit Tester, a piece of Apollo Ground Support Equipment.

This equipment was connected to the RR CDU's and to ATCA power. Monitoring of the CDU's on the DSKY (V16N72) showed a rapid, erratic variation of the shaft and trunnion angles. In order to get a better look at the effect, we set up an EMemory loaded special downlist. This program is prepared by Mr. Jimmy Glassman following the format of the so-called 70 word list used in the IMU Performance Test K START Tapes (-K00081). In this case it displays an ID word, 6 DP words each containing shaft and trunnion CDU counters, and two words of channels. In this way we have essentially a 20 ms (the interval between downlink transmissions) monitor on the angles. Examination of some printout of this list (Quick Look) showed total excursions of about 13 deg. almost entirely at 6.4 KC. It is estimated that the reversals which were at slow rate resulted in an average 15% pulse loss compared to a continuous 6.4 KC slewing. However, it is felt that this is representative of the condition in the vehicle. Converting to central processor time loss from both CDU channels this i 13% instead of 15%.

Since the FMES/FCI LABORATORY was coming back on line preparator to doing LUMINARY 1B testing using LMY99 (LUMINARY 1A, the Apollo 11 Flight Program) it seemed useful to run a nominal descent such as in Apollo 11, with Marty's setup inputting the RR CDU's. No attempt was made to reproduce exactly the Flight's IC's or to follow exactly the trajectory (flight path). Our plan was to call up the V16N68 monitor normally, leaving them on a while to see if an alarm condition was induced. If one occurred we would reestablish the monitor. The idea here was that if we had the basic situation, we could get more samples of the alarms. The spare location-#26-in the Descent an Ascent downlist was patched to display ALMCADR so we could see which Job was being called at overflow. Of course it was understood tght the Job being called at overflow might just be a victim rather than one tha was in trouble. In the end we would go to P 66 rather than going automatic all the way. Again, there was no attempt to follow Neil's profile in P 66.

DISCUSSION OF THE PERFORMANCE OF THE SIMULATION RUN

The performance of this run, summarized in TABLE 1, was in signii icant agreement with the Apollo 11 landing on the moom based on data we have seen to date. The following references are pertinent:

LAV-500-940; Clint Tillman; Program Alarms in Powered Descent-Apo -11

MIT/IL Letter AG#370-69; George Cherry; Exegesis of the 1201 and 1202 Alarms Which Occurred During the Mission G Lunar Landing.

No alarm occurred in the first V16N68 monitor for a period longer than the 12 sec in the flight so V57E was executed. Thereafter, 120 alarms came after V16N68's were entered in P 63. The last monitor started in P 63, overlapped into P 64: a 1201 occurred. A second 120 came in P 64 without DSKY entry as in the flight. Finally, there was one more 1202, but unlike the flight this was in P 66 and after V16

There were no so-called multiple alarms-that is, one right on top of another or in fast succession, say at the rate of SERVICER (every 2 sec). There were no 1203's. The RR CDU Fail indication, Ch30B07, was present throughout the run. This should be, if the resolver setup was working. Trajectory performance data has not been reviewed, but the Software Restarts did not cause any other perturbations noticeabl to the Pilot (Dick Brent) and the landing seemed nominal.

DISCUSSION OF SOME SOFTWARE OBSERVATIONS

Having ALMCADR* patched onto the downlist permits us to obtain deepe insight into the situation and to confirm some of the comments in George's AG Letter. Seven alarms were induced. All were triggered by legitimate Jobs according to the Job Table appended to the letter.

Three amplifications to George's table must be noted:
1.) MAKEPLAY is a FINDVAC or NOVAC Job depending on whether or not it is making a flashing display. In P 63 and P 66 it displays V06N63 and V06N60 respectively and so is a NOVAC. This agrees with our run. In P 64 it starts out with a FV06N64 and so is a FINDVAC. The flash is a request or cue to the Astronaut to enable LPD (the Landing Point Desi nator). If he does (with a PRO), the display reverts to V06N64 and MAKEPLAY is once again a NOVAC.
2.) There is an additional FINDVAC Job, RODCOMP (Priority 22). It is established every second only in the Rate of Descent Program, P 66.
3.) LRHJOB supervises taking one Landing Radar altitude sample every 2 sec. While it is true the radar is sampled for 80 ms, the overall process of sampling and transferring takes 90 ms. And up to another 10 ms may be needed due to the relative timing of the request to the LGC clocks. The Job may sleep for up to 100 ms.
LRVJOB is similar, but it supervises 5 "consecutive" samples of a single LR velocity parameter every 2 sec. This makes a block of time about 0.5 sec long during which the Job is sleeping in the NOVAC queu

Let us consider the situations at the 1201 alarms (No VAC areas). There was one in the flight, in P 64 prior to enabling LPD, so MAKEPL was a FINDVAC at that point. In the simulation there were two 1201's both in P 64. LPD was not enabled in this run. The other FINDVAC Jobs possible in P 64 were SERVICER and HIGATJOB. HIGATJOB is essentially a one-shot affair, supervising the re-positioning of the LR. In the flight the LR was re-positioned about 5 sec after P 64 was displayed and about 40 sec before the AC 1201. In the simulation-see TABLE 1-t LR repositioned 8 sec after P 64 and 20 sec before the first 1201. HIGATJOB could have contributed little to these alarms. While the fir AC 1201 in the simulation occurred with the V16N68 monitor running, note that MONDO calls are NOVAC's and could not lead directly to an overload of the VAC area queue. Of course the job does represent an additional time load on the central processor.

I believe this evidence substantiates George's conclusion that th 1201 alarm codes were due to SERVICER not getting enough time on the central processor to complete its work and so becoming multiple sched uled. A ubiquitous SERVICER, in conjunction with the NOVAC class Job could also overload the larger coreset area queue, leading to 1202 alar codes in P 63 and in P 64, after enabling LPD. In P 66 SERVICER does not have to do guidance, but RODCOMP now requires a coreset every second. The overall loading in P 66 must be more like P63 ~~[illegible]~~ since in on case-the flight-there was no alarm while in another-the simulation-there was one 1202 after about 64 seconds, and a V16N68.

*A note of caution in decoding the bank constant word of ALMCADR. The EXECUTIVE routine only saves the caller's FBANK. It does not supply the contents of EBANK or FEXT, Channel 7, so if FBANK indicates a Superbank the two possible alternates must each be checked. This wa the case with the MONDO call.

The Software Restart approach to handling internal computer sched uling overloads consists of two major steps:

1) Terminating all activity that has come under its control. This ca include normal programed activity required for automatic operatio "externally" requested activity such as Crew selected displays an Extended Verbs; and unnecessarily scheduled activity.
2) Re-initiating only the normal, baseline, programed activity.

The visible objective is to maintain a baseline program activity that will sustain at least minimum mission performance-the inner curative mechanism may vary considerably with the situation. Two cases are ill ustrated here. We see from the flight data and this simulation that in P 63 there was a conflict of three interests: high baseline activi an unplanned loss of about 15% of available central processor time, a a fairly time consuming external display request (the V16N68 monitor) In this case the restart system saved the day by killing the external request as necessary.

The curative mechanism at work in the P 64 case was much more sophisticated and the struggle more dramatic. Here the contending elements must have been a baseline program activity even somewhat hig er than in P 63 and the unplanned for time loss. And now the effect of several restarts was to slightly reduce the amount of purposeful work done by the central processor when considered over a larger inte val than the 2 sec SERVICER period. (This was accomplished, of course just by knocking down all the scheduled Jobs and Tasks and starting again.) This might be visualized as occasionally adjusting the SERVIC period, lowering its rate while trusting that guidance-control would not suffer noticeably.

The amount of time overload that could be handled by the restart system is hard to say. It is immediately dependent on the dynamic rat in the guidance at the time and their interaction with control(DAP) dynamics and/or other unadjustable periods and time constants.

The "restart period" in P 64 in the flight was about 28 sec, an order of magnitude greater than SERVICER's. Apparently, flight perfor ance was not perturbed. George's letter discusses briefly the idea of programing the guidance to be based on a Servicer period that would vary automatically to accommodate work load fluctuations. Folks may recall that in November 1968 The MIT/IL prepared PCR 650 "Variable Guidance Period", which covers this. It was for LUMINARY 1A and was disapproved January 21 1969.

Some folks may also recall that during FMES/FCI LABORATORY testin of SUNBURST, the LM-1 Flight Program, we subjected MP 11 (DPS 2) to a heavy profile of random restarts. Domjan and Beardsley of the Perform ance Analysis Group, who were studying the Guidance-Control Interacti problem, looked at one such run and concluded that the restarts had improved matters. It would be hard to directly project this to the present since there have been significant changes. For example: the guidance phases were modified; FINDCDUW, the guidance-control interfa routine, is new; the DAP itself is new; SUNBURST did not drive the lateral velocity display meters or the altitude/ altitude rate meters In LM-1 the effect of restarts during descent guidance appeared to be to decouple somewhat the guidance-control loops. MIT/IL analysis of guidance-control interaction prior to the release of LUMINARY 1A , le to modification of the guidance equations to compensate for computati engine throttle, FINDCDUW, and attitude control lags (as specified in PCR 731).

forward

CONCLUSIONS

1. Marty Dvorkin's resolver setup provides an input to the RR CDU's that adequately simulates the vehicle configuration when the pane control is in SLEW or AUTO.
   This arrangement should be used to verify the fix (PCR 848) in LUMINARY 1B.

2. The diagnosis of the alarm problem in Apollo 11 has been verified in a very comprehensive hybrid simulator-The FMES/FCI LABORATORY.

TABLE I SUMMARY OF RUN.

TIME FROM ENGIN ON (PDI), sec	TIME INTERV. OF Interest	EVENT	Contents of ALMCADR	Machine Address and General Area of Calling Program	Job Called and Type	Prog No.
0		ENGINE ON				63
314.31	34	LRALT LITE OFF V16N68E Release Monitor V57E (Set F11B08 LRINH)				
360.22 368.23	8	V16N68E AC1202	03457 76000	37,3457, READACCS	SERVICER (FINDVAC)	
386.23 440.22	54	V16N68E AC1202	02654 20000	10,2654 GODSPRS1	MAKEPLAY (NOVAC)	
450.22 464.22	14	V16N68E AC1202	03457 76000	37,3457 READACCS	SERVICER (FINDVAC)	
480.22 488.22	8	V16N68E AC1202 (V74E)	03311 62000	41,3311 MONREP (Pinball)	MONDO (NOVAC)	
502.21	30	V16N68E				63
504.21 512.24 532.23 582.63	28 50	LR in Pos. 2 AC1201 (V74E) AC1201 (V74E)	03457 76000 03457 76000	37,3457 READACCS 37,3457 READACCS	SERVICER (FINDVAC) SERVICER (FINDVAC)	64 64
612.87 676.86	64	V16N68E AC1202 (V74E)	02654 200[illegible]	10,2654 GODSPRS1	MAKEPLAY (NOVAC)	66 66 68

(V74E)

6